PROJECT ON
COMPARISON OF FINANCIAL INVESTMENT & RETURN ON THE CAPITAL IN THE MINING INDUSTRIES OF THE DEVELOPING COUNTRIES – CASE STUDIES

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

BY

Ashish Kumar Jindal

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA - 769008

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Under the Guidance of

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Rourkela

CERTIFICATE

This is to certify that the thesis entitled "**Comparison of financial investment & return on the capital in the mining industries of the developing countries – case studies"** submitted by Sri Ashish Kumar Jindal (Roll No. 107MN021) in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not formed the basis for the award of any Degree or Diploma or similar title of any University or Institution.

Date:

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ACKNOWLEDGEMENT

My heart pulsates with the thrill for tendering gratitude to those persons who helped me in completion of the project.

The most pleasant point of presenting a thesis is the opportunity to thank those who have contributed to it. Unfortunately, the list of expressions of thank no matter how extensive is always incomplete and inadequate. Indeed this page of acknowledgment shall never be able to touch the horizon of generosity of those who tendered their help to me.

I record my sincere gratitude to Prof. B. K. Pal, Professor, Department of Mining Engineering for assigning us the project "*COMPARISON OF FINANCIAL INVESTMENT & RETURN ON THE CAPITAL IN THE MINING INDUSTRIES OF THE DEVELOPING COUNTRIES – CASE STUDIES*". It is not possible to acknowledge sufficiently his important contribution of talent and time given unselfishly in proceeding with this work. His overall constructive criticism has helped us to present our work in the present form.

We would also like to convey our sincere gratitude and indebtedness to the faculty and staff members of Department of Mining Engineering, NIT Rourkela, for their help at different times.

Last but not the least; we would like to thank all our friends who have been a constant source of help to us.

DATE:

Ashish K. Jindal

(107MN021)

Contents

ABSTRACT

Mining is one of the most important industries in our society and has been for ages. The resources extracted from the earth are fundamental in providing us with the quality of life we enjoy each day from the cars we drive to our cell phones we use. The food we eat was produced and harvested by machinery formed out of metals and mineral resources. The clothes we wear are treated and coated with dyes created from a variety of elements. Some fabrics are completely constructed from mined materials. It is not surprising to see that mineral resources have been widely spread throughout the world in almost every continent. Economical extraction and use of these resources is what is essential to every country in its development.

For a country to effectively mine its natural resources is one of its biggest advantages and assets. In this age when every item seems to be linked to mining directly or indirectly a country's mineral wealth is far more valued above everything else. And as we read this not only the developed countries but also the developing countries are in the forefront of the mining industry. Small-scale mining is expanding rapidly and often uncontrollably in many developing countries. Slowly this small scale mining is turning into a full-fledged industry. As many as 80-100 million people worldwide depend for their livelihoods on the often scant proceeds of small-scale mining, roughly the same amount as for the more visible, large-scale mining sector.

List of Figures

List of Tables

Chapter – 1

Introduction

General

Objective

Introduction

1.1 General

The project aims at comparing the financial aspects of total mining industry of some select developing countries.

As of new certain factors have been identified that will help in carrying out a comparison

- Gross domestic product (GDP)
- GDP Growth Rate
- Mining industry contribution to GDP
- Man power employed in mining industry
- Annual production
- Current reserves

Countries under consideration:

1. India
2. Australia
3. Germany
4. Russia

Total recoverable coal reserves around the world are estimated 909 billion tons reflecting current reserves to production ratio of 129 years. Historically, approximates of world recoverable coal reserves, and relatively stable, have decreased gradually from 1,145 billion tons (in 1991) to 1,083 billion tons (in 2000) and 909 billion tons in 2008.

Coal deposits are widely available; Mainly world's recoverable reserves of coal are located in 5 regions. These Five regions have 82 percent of total of the world's recoverable reserves.

United States (29%),
Russia (19%),
China (14%),
Other non-OECD Europe, Eurasia (10%), and

Australia, New Zealand (9%).

In 2007 these five regions, taken composed, produced 4.9 billion tons of coal, representing 71% of total world coal production. By coal quality, Top rank coal, anthracite and bituminous coal account for 50% of total of the world's estimated recoverable coal reserves on basis of tonnage, sub-bituminous coal accounts for 32 percent, and lignite accounts for 18percent.

India

Coal India, the world's largest coal producer, produces more than 80% of the country's dry-fuel requirement and any fluctuation in its supply affects power generation of country.

According to the 2010 BP Statistical Energy Survey (BP is one of the world's leading international oil and gas companies), India had end in 2009, coal reserves of 58600 million tonnes, 7.09% of coal of the world total. The world's largest reserves are held by the India, China, Russia, Australia and USA.

Coal India (CIL) has following coal producing subsidiary companies.

- Central Coalfields (CCL),
- Eastern Coalfields (ECL),
- Bharat Coking Coal (BCCL)(Dhanbad),
- Northern Coalfields (NCL)(Nagpur),
- Western Coalfields (WCL),
- Southern Eastern Coalfields (SECL) (Bilaspur),
- Mahanandi Coalfields (MCL) (Sambalpur),
- The Central Mine Planning & Design Institute (CMPDI)

CMPDI is dedicated with the job of provides total research and consultancy support to the coal India and other coal industries.

After coal India, Major producer of coal is Singerani Collieries Company (SCCL) that is Andhra Pradesh government under taking is located in Andhra Pradesh (AP). SCCL has 37 working underground and 13 working opencast mines.

Australia

In Australia, Coal is mined in most of state. Coal is used to generate electricity and is exported to other countries. Australia exports 75% of the mined coal, mostly to eastern Asia. In 2000-01, 258.5 million tonnes of coal was mined, and out of this 193.6 million tonnes exported, In 2008–09 It was risen to 261 million tonnes of exports. 85% of coal is being used for electricity production in Australia. Australia is the world's top coal exporter.

In Australia, A large number of multinational mining companies operate:

- BHP Billiton
- Newcrest
- Rio Tinto
- Xstrata
- Alcoa
- Chalco
- Shenhua
- Alcan

There are also a lot of small mining and mineral exploration companies listed on the Australian Stock Exchange (ASX). Overall, the resources sector represents almost 20% of the ASX market by capitalization, and almost one third of the companies listed.

Germany

RAG, also know as Ruhrkohle AG, is the largest coal mining corporation of German and having company headquarters in Herne in the Ruhr area.

The Ruhr Area in North Rhine-Westphalia, Lower Lusatia and the Central Germany has some lignite mining area of the coal-mining regions.

German has five operating hard coal mines (small sectors) in the End of 2010:

- Bergwerk Ibbenbüren, Ibbenbüren,

- Zeche Auguste Viktoria, Marl,
- Bergwerk Prosper-Haniel, Bottrop,
- Bergwerk West, Kamp Lintfort,
- Bergwerk Saar, Saarlouis.

Main coal producing mining companies of Germany

- ✓ RAG Aktiengesellschaft
- ✓ Deutsche Bergwerks- und Hüttenbau
- ✓ Vereinigte Stahlwerke AG

Russia

Russia is fifth largest producer of coal, and having the 2nd largest reserves (estimated at 175 billion tonnes). The majority of Russian coal is located behind the Ural Mountains in Siberia in Russia. In 1999 almost a third part of coal mining was privatized business. After that the industries have focused in hands of few companies - coking coal producers are integrated with the steel makers, and two Russian leaders in steam coal emerged. Russian coal miners and workers have newly electioneered for improvements in their working conditions, leading to some change.

Coal companies of Russia are:

- Arktikugol, Mechel
- Raspadskaya (company)
- Siberian Coal Energy Company
- SIBPLAZ
- Yakutugol

GLOBAL MINING INDUSTRY IN PERSPECTIVE

In 2009 the global mining industry practiced rapid recovery of market capitalization lost in the previous year of 2008. The market capitalization of the Top 40 increased incredible 118%, or $696 billion, reaching levels just little of the peak prior to the global financial crisis. The recovery has largely been driven by a sharp resurrection in commodity prices throughout the second half of 2009 and an whole improved investment climate. In comparison to the prior year, the market capitalization cut-off for inclusion in the Top 40 has increased to levels similar to those seen in 2007, from $2 billion in 2008 to around $6.5 billion in 2009. Throughout the global financial crisis, the mining sector showed greater volatility than the broader market—rising higher in early 2008, but falling faster through the year to a deeper low point, as many speculative investors scrambled to close positions. Equally, it has gained momentum quicker than the rest of the market and, by year-end, had surged ahead as the industry moved back to the boom.

1.2 OBJECTIVES

The objectives of this project are clearly outlined below:-

- ✓ To assign weights to the different parameters chosen for the comparison using Analytic Hierarchy Process (AHP) .
- ✓ To normalize each and every parameter and obtain a standard weighting measure for easier calculations for variables which do not have an exactly numerical consequence.
- ✓ Calculation of points for each parameter and summing them to get an index which gives a comparison for developing countries.

Chapter -2

Literature reviews

GDP

GDP growth rate

Current reserves

Production

2.1 Gross Domestic Product - GDP

“The monetary value of all the finished goods and services produced within a country's borders in a specific time period, though GDP is usually calculated on an annual basis. It includes all of private and public consumption, government outlays, investments and exports less imports that occur within a defined territory.

GDP= C + G + I + NX

where:

"**C**" is equal to all private consumption, or consumer spending, in a nation's economy

"**G**" is the sum of government spending

"**I**" is the sum of all the country's businesses spending on capital

"**NX**" is the nation's total net exports, calculated as total exports minus total imports.

(NX = Exports - Imports)

GDP is commonly used as an indicator of the economic health of a country, as well as to gauge a country's standard of living. Critics of using GDP as an economic measure say the statistic does not take into account the underground economy - transactions that, for whatever reason, are not reported to the government. Others say that GDP is not intended to gauge material well-being, but serves as a measure of a nation's productivity, which is unrelated.”

2.2 GDP growth rate

“GDP (Gross Domestic Product) is the total dollar amount of all goods and services produced in the U.S. The GDP growth rate is the percentage increase or decrease of GDP from the previous measurement cycle. Even though the BEA (Bureau of Economic Analysis) reports quarterly, the growth rate is annualized so it can be compared to the previous year.

The GDP growth rate is driven by retail expenditures, government spending, exports and inventory levels. Rises in imports will negatively affect GDP growth.

The GDP growth rate is the most important indicator of economic health. If GDP is growing, so will business, jobs and personal income. If GDP is slowing down, then businesses will hold off investing in new purchases and hiring new employees, waiting to see if the economy will improve. This, in turn, can easily further depress GDP and consumers have less money to spend on purchases. If the GDP growth rate actually turns negative, then the U.S. economy is heading towards a recession."

2.3 Current reserves

"Amongst the major energy sources, coal is once again the most rapidly growing fuel on a global basis. While questions regarding the size and location of reserves of oil and gas abound, coal remains abundant and broadly distributed around the world. Economically recoverable reserves of coal are available in more than 70 countries worldwide, and in each major world region. With authorities reporting some 850 billion tonnes of coal as currently recoverable (the geological resource is far larger), it is clear that coal will be with us for many decades, if not centuries, to come.

The fact that global coal reserves at end-2005 were, at 847.5 billion tonnes, some 61.5 billion tonnes or 6.8% lower than the corresponding total at end-2002 represents more of a refinement than a revision. After centuries of mineral exploration, the location, size and characteristics of most countries' coal resources are quite well known. What tends to vary much more than the assessed level of the resource (in other words, the potentially accessible coal in the ground) is the level classified as proved recoverable reserves (that is the tonnage of coal that has been proved by drilling etc. and is economically and technically extractable)."

2.4 Production

Coal is mined commercially over 50 countries of world. Over 7k Mt/yr of hard coal is currently mined, a substantial rise over the past 25 years. In 2006, the world production of brown coal and lignite coal were slightly over 1,000 Mt, Germany was the world's largest brown coal producer having 194.4 Mt and China second at 100.6 Mt in 2006.

Coal production has grown-up fastest in Asia, whereas Europe has weakened. The top coal mining nations (figures in brackets are estimation of total coal production in millions of tons in 2009) are:

- China (3,050 Mt)
- USA (973 Mt)
- India (557 Mt)
- Australia (409 Mt)
- South Africa (250 Mt)
- Russia (298 Mt)
- Indonesia (252 Mt)
- Poland (135 Mt)
- Kazakhstan (101 Mt)
- Colombia (72 Mt)

Chapter- 3

Analytic Hierarchy Process

Introduction

THE AHP THEORY

STRENGTHS AND WEAKNESSES OF THE AHP

3.1 Analytic Hierarchy Process (AHP)

"The Analytic Hierarchy Process (AHP) is a structured technique for dealing with complex decisions. Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem—it is a process of organizing decisions that people are already dealing with, but trying to do in their heads.

Based on mathematics and psychology, the AHP was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

The Analytic Hierarchy Process (AHP) is due to Saaty (1980) and is often referred to, eponymously, as the Saaty method. It is popular and widely used, especially in military analysis, though it is not, by any stretch of the imagination, restricted to military problems.

Three features of AHP differentiate it from other decision making approaches:

(i) its ability to handle both tangible and intangible attributes,
(ii) its ability to structure the problems in a hierarchical manner to gain insights into the decision making process, and
(iii) its ability to monitor the consistency with which a decision maker uses his/her judgment.

3.2 THE AHP THEORY

Consider n elements to be compared, C1, C2… Cn and denote the relative 'weight' (or priority or significance) of Ci with respect to Cj by aij and form a square matrix A= (aij) of order n with the constraints that aij = 1/aji, for i ≠ j, and aii = 1, all i. Such a matrix is said to be a reciprocal matrix. The weights are consistent if they are transitive, that is aik = aijajk for all i, j, and k. Such a matrix might exist if the *aij* are calculated from exactly measured data. Then find a vector ω of order n such that $A\omega = \lambda\omega$. For such a matrix, ω is said to be an eigenvector (of order n) and λ is an eigenvalue. For a consistent matrix, $\lambda = n$. For matrices involving human judgement, the condition aik = aijajk does not hold as human judgements are inconsistent to a

greater or lesser degree. In such a case the ω vector satisfies the equation Aω= λmaxω and λmax ≥ n. The difference, if any, between λmax and n is an indication of the inconsistency of the judgements. If λmax = n then the judgements have turned out to be consistent. Finally, a Consistency Index can be calculated from (λmax-n)/ (n-1). That needs to be assessed against judgments made completely at random and Saaty has calculated large samples of random matrices of increasing order and the Consistency Indices of those matrices. A true Consistency Ratio is calculated by dividing the Consistency Index for the set of judgments by the Index for the corresponding random matrix. Saaty suggests that if that ratio exceeds 0.1 the set of judgments may be too inconsistent to be reliable. In practice, CRs of more than 0.1 sometimes have to be accepted. CR =0 means that the judgements are perfectly consistent.

The following table is used to determine the relative importance of one parameter vs the other when it comes to assigning pairwise combinations.

Table 3.1: The Saaty Rating Scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgement slightly favour one over the other.
5	Much more important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate Values	When compromise is needed

A comparison matrix is set up by comparing pairs of criteria or alternatives. A scale of values ranging from 1 (equally important) to 9 (extreme more important) was used to express evaluators' preferences. This pairwise comparison enables the decision maker to measure the contribution of each factor to the objective independently, thereby simplifying the decision-making process. The final step synthesizes priorities to calculate a composite weight for each alternative, based on preferences derived from the comparison matrix.

The eigenvector calculations are one of the most important steps of the process as they give the normalized weights.

Step1 – Multiply the entries of each row of the matrix.

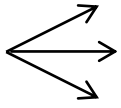
Step2 – Take the n^{th} root of the product.

Step3 – The n^{th} roots of all the rows are summed and that sum is used to normalize the eigenvector elements to add to 1.

Step4 – calculate the consistency ratio (CR) and consistency index (CI) if required by multiplying the right matrix of the judgements of the eigenvector hereby obtaining a new vector.

Table 3.2: Consistency Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Consistency Ratio (CR) 

< 0.1; trustworthy

>≈ 0.1; just accepted

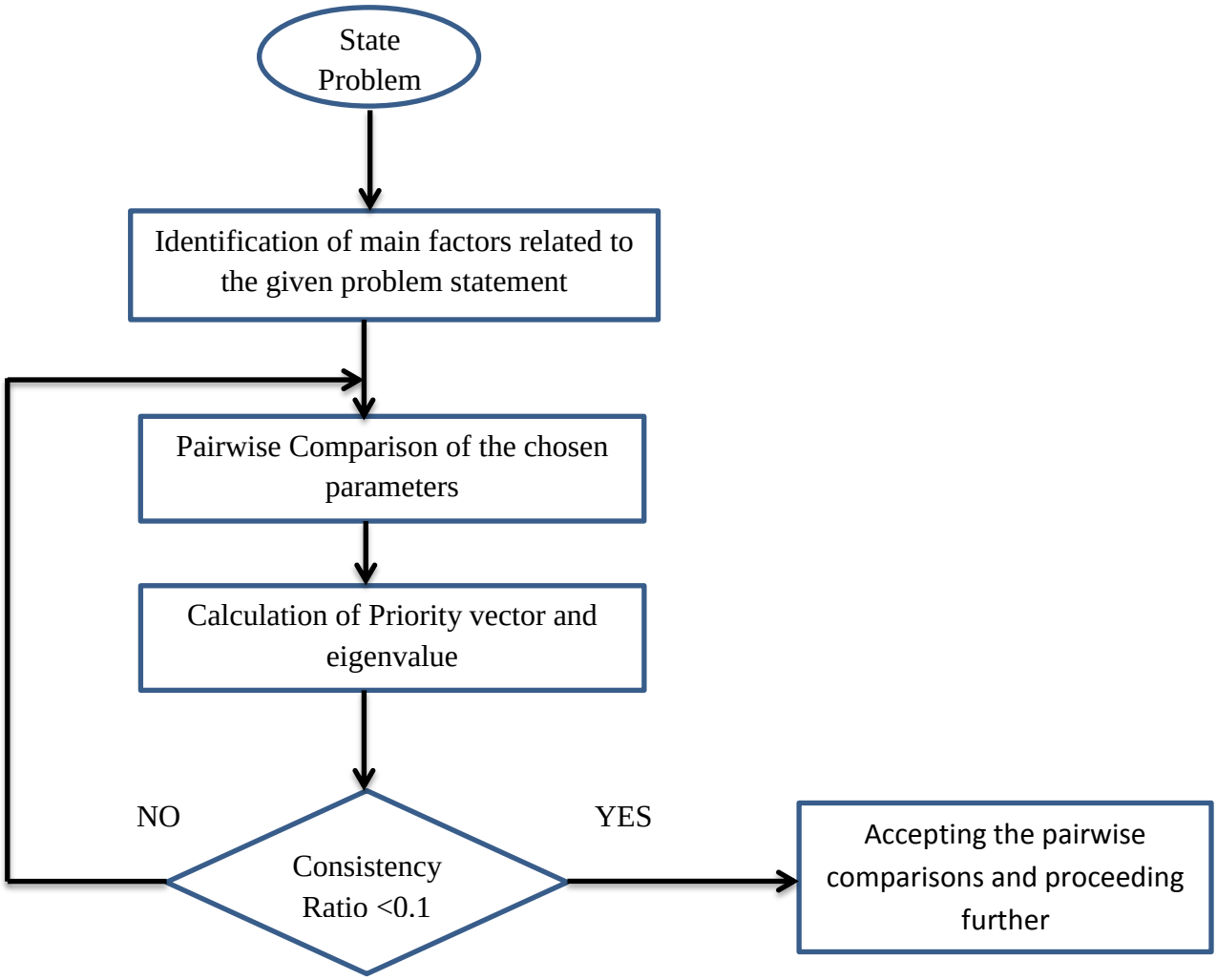
≈0.8-0.9 completely untrustworthy

The Consistency Index for a matrix is calculated from (λmax-n)/ (n-1). The final step is to calculate the Consistency Ratio for this set of judgements using the CI for the corresponding value from large samples of matrices of purely random judgments using the table from Saaty's book in which the upper row is the order of the random matrix, and the lower is the corresponding index of consistency for random judgements.

3.3 STRENGTHS AND WEAKNESSES OF THE AHP

Like all modelling methods, the AHP has strengths and weaknesses. The main advantage of the AHP is its ability to rank choices in the order of their effectiveness in meeting conflicting objectives. If the judgements made about the relative importance of, in this example, the objectives of expense, operability, reliability and flexibility, and those about the competing machines' ability to satisfy those objectives, have been made in good faith, then the AHP calculations lead inexorably to the logical consequence of those judgements. It is quite hard – but not impossible – to 'fiddle' the judgements to get some predetermined result. (In MOA, it *is* impossible to do that.) The further strength of the AHP is its ability to detect inconsistent judgements. The limitations of the AHP are that it only works because the matrices are all of the same mathematical form – known as a positive reciprocal matrix. The reasons for this are explained in Saaty's book, which is not for the mathematically daunted, so we will simply state that point. To create such a matrix requires that, if we use the number 9 to represent 'A is absolutely more important than B', then we have to use 1/9 to define the relative importance of B with respect to A. Some people regard that as reasonable; others are less happy about it.

The other seeming drawback is, that if the scale is changed from 1 to 9 to, say, 1 to 29, the numbers in the end result, which we called the Value For Money Vector, will also change. In many ways, that does not matter as the VFM (not to be confused with the Viable Final Matrix) simply says that something is relatively better than another at meeting some objective."


State Problem
Identification of main factors related to the given problem statement
Pairwise Comparison of the chosen parameters
Calculation of Priority vector and eigenvalue
NO
YES
Consistency Ratio <0.1
Accepting the pairwise comparisons and proceeding further

Chapter- 4

COMPARISON OF COUNTRIES

COUNTRIES

CALCULATION OF RELATIVE WEIGHTS

STANDARDIZATION OF 2 MATRIXES

4.1 Countries

Countries under consideration:

1. India
2. Australia
3. Germany
4. Russia

These 4 countries are developing countries in mining sector.

India

Gondowana Coals are most important in India and account for more than 90% of coal production in country. The land mass of southern hemisphere was united with South Africa, India, Australia and possibly South America. India drifted north-east relative to Africa and the Gondowana landmass was exposed to sub-aerial conditions for a long period of time. The initiation of Gondowana period is marked by a glacial period (evidenced by Talcher Series). Climate changed to a more temperate condition in later period melting snow and allowing prolific growth of vegetation. This huge vegetation got buried and produced Gondowana Coals. The land subsidence began in the east giving rise to a great depth of Barakar and Ranigunju measures. The great depth along with earth movement allowed the coal seam to lose moisture and volatile matter and change in chemical conditions and sometimes converted to coke (example: Barakar Strata). To the west, subsidence was less as evidenced by thin and poor quality coal seams.

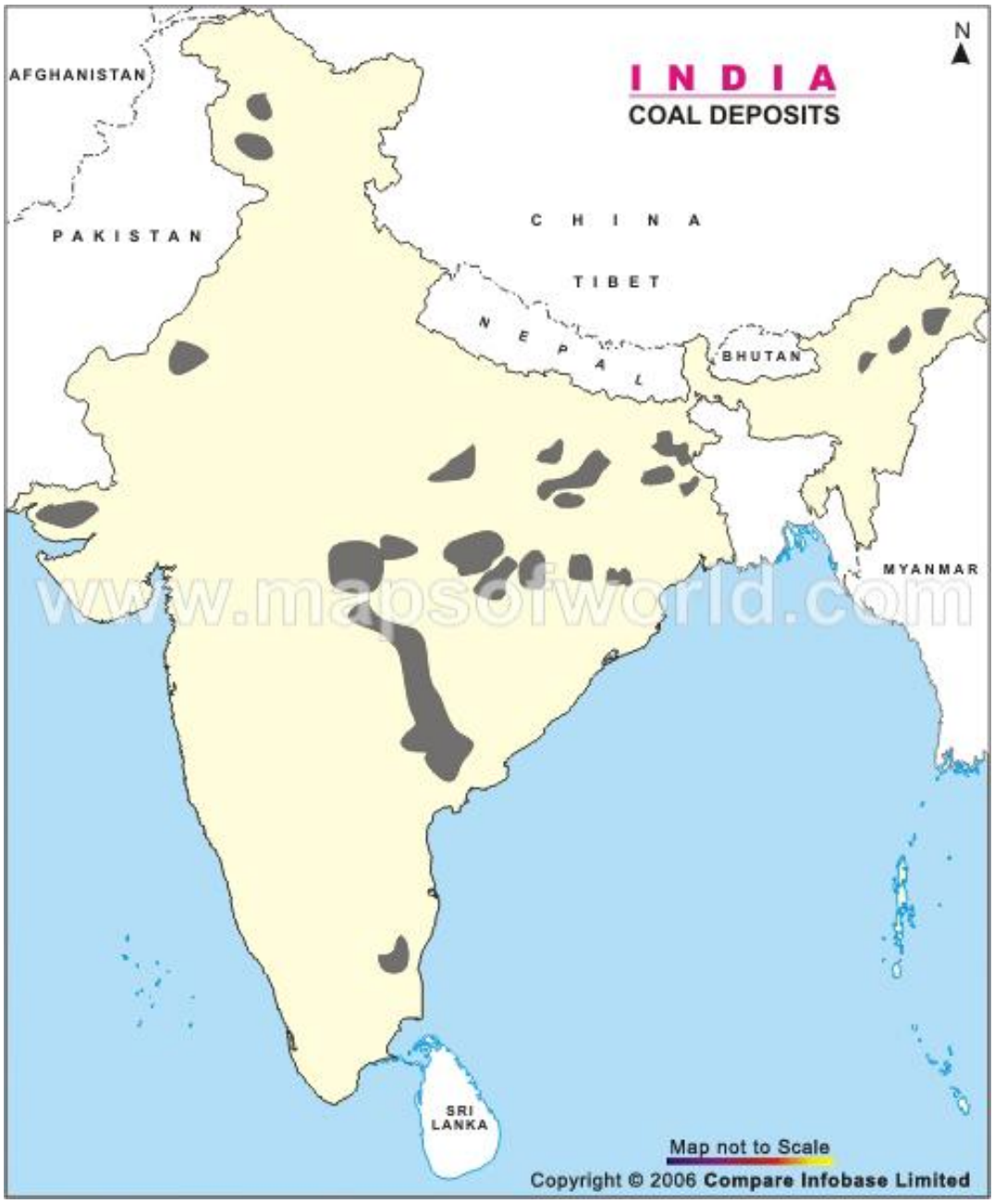


Fig 4.1: Map of coal deposits in india

Australia

In Australia, Coal is mined in most of state. Coal is used to generate electricity and is exported to other countries. Australia exports 75% of the mined coal, mostly to eastern Asia. In 2000-01, 258.5 million tonnes of coal was mined, and out of this 193.6 million tonnes exported, In 2008–09 It was risen to 261 million tonnes of exports. 85% of coal is being used for electricity production in Australia. Australia is the world's top coal exporter.

In Australia, Coal mining has been the topic of criticism from members of the environmental movement, because of burning coal releases carbon dioxide, This is generally contribute to climate change, global warming, sea level rise and the effects of global warming on world.

Fig 4.2: Map of coal deposits in Australia

Germany

RAG also knows as Ruhrkohle AG, is the largest German coal mining corporation having company headquarters in Herne in the Ruhr area.

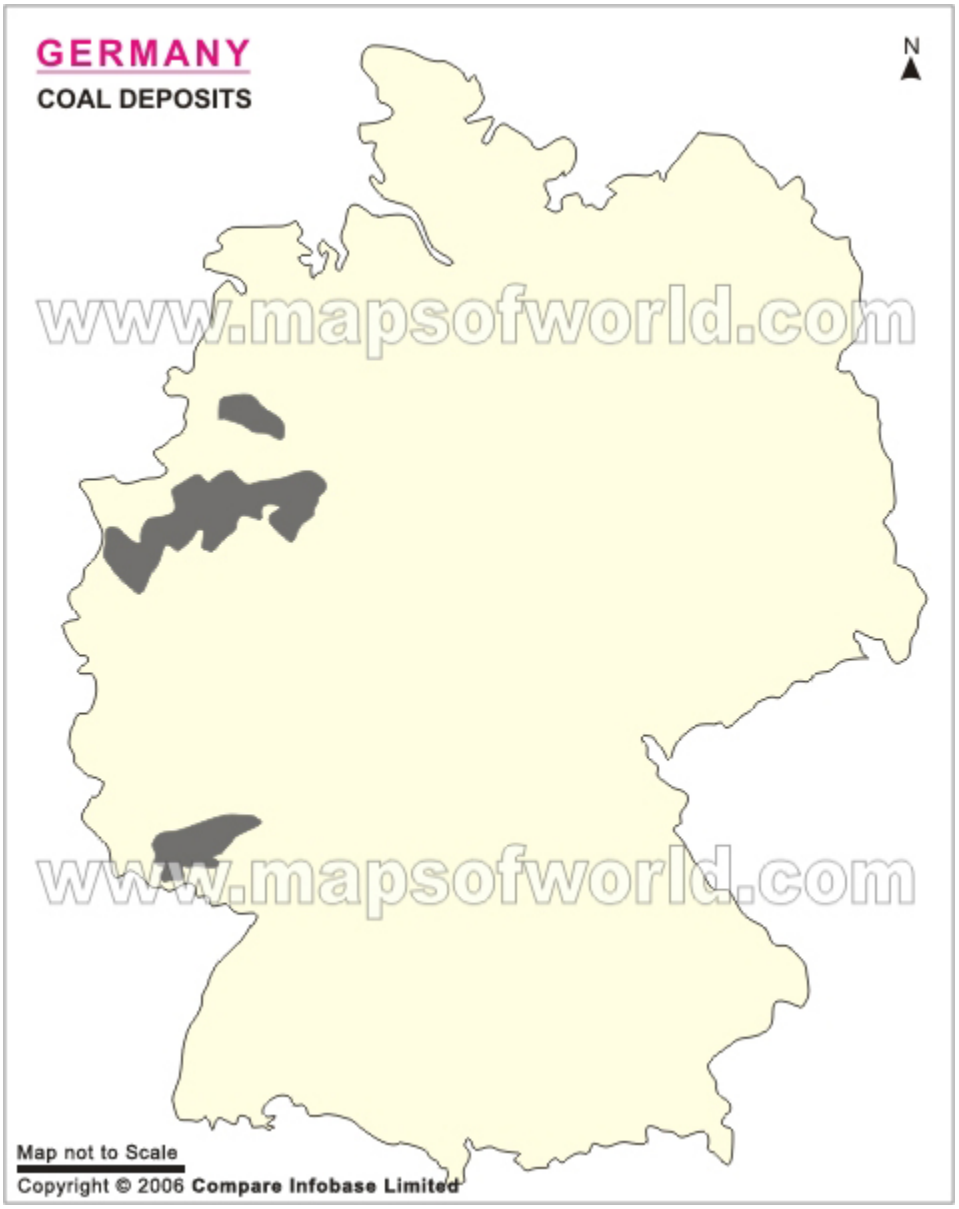


Fig 4.3; Map of coal deposits in Germany

Russia

Russia is fifth largest producer of coal, and having the 2nd largest reserves (estimated at 175 billion tonnes). The majority of Russian coal is located behind the Ural Mountains in Siberia in Russia.

Fig 4.4; Map of coal deposits in Russia

Table 4.1: Data of different parameters of respective countries

Parameters	Country name			
	India	Australia	Germany	Russia
GDP (in Billion US$)	1296	925	3347	1477
GDP growth rate in %	8.80%	1.20%	0.70%	3.80%
Mining industry contribution to GDP (in%)	5.5	5.6	1	2.4
Man power employed (in lacs)	3.98	0.45	0.59	0.34
Imports (in Mts)	67	NA	38	NA
exports (in Mts)	NA	259	NA	116
Current reserves (Bt)	212	75	40	157
production (MTs/yr)	526Mt	335Mt	184Mt	229Mt

4.2 CALCULATION OF RELATIVE WEIGHTS

COUNTRY vs PARAMETERS Matrix

1. GDP

Table 4.2: Country vs Country (GDP)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth ROOT OF PRODUCT OF VALUE	EIGEN VECTOR (E_i)	λmax
INDIA	1	3	1/7	1/3	0.615	0.097	4.24
AUSTRALIA	1/3	1	1/9	1/3	0.333	0.0527	4.17
GERMANY	7	9	1	5	4.21	0.6665	4.1
RUSSIA	3	3	1/5	1	1.158	0.1833	4.17
TOTAL					6.316	0.9995	

Consistency Ratio calculation (n=4)

Mean λmax = 4.17

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.0567$

Consistency Ratio (CR) = 0.0567/0.9 =0.063

CR= 0.063 < 0.1

Hence the pairwise judgements are trustworthy and accepted.

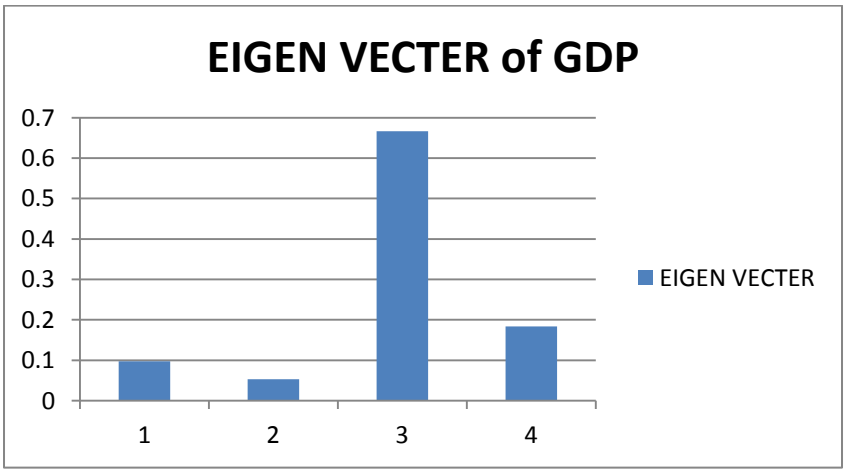


Figure 4.5: Graph of Country vs Country (GDP)

2. GDP Growth Rate

Table 4.3: Country vs Country (GDP growth rate)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth ROOT OF PRODUCT OF VALUE	EIGEN VECTOR of GDP growth rate (E_i)	λmax
INDIA	1	1/7	1/8	1/5	0.245	0.0416	4.237
AUSTRALIA	7	1	1/2	4	1.934	0.3291	4.12
GERMANY	8	2	1	5	2.99	0.5088	4.13
RUSSIA	5	1/4	1/5	1	0.707	0.1203	4.258
TOTAL					5.876	0.9998	

Consistency Ratio calculation (n=4)

Mean λmax = 4.186

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.062$

Consistency Ratio (CR) = 0.062/0.9 =0.068

CR= 0.068 < 0.1

Hence the pairwise judgements are trustworthy and accepted.

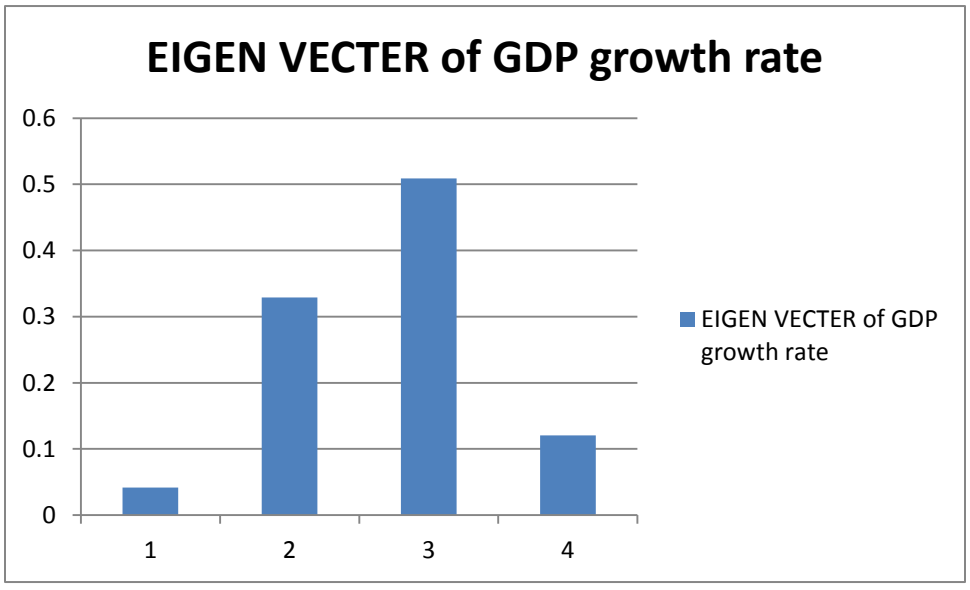


Figure 4.6: Graph of Country vs Country (GDP Growth rate)

3. Mining contribution in GDP

Table 4.4: Country vs Country (Mining contribution in GDP)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth ROOT OF PRODUCT OF VALUE	EIGEN VECTOR (E_i)	λmax
INDIA	1	3	1/9	1/7	0.467	0.0698	4.28
AUSTRALIA	1/3	1	1/9	1/7	0.27	0.0403	4.26
GERMANY	9	9	1	3	3.94	0.5892	4.2
RUSSIA	7	7	1/3	1	2.01	0.3005	4.22
TOTAL					6.687	0.9998	

Consistency Ratio calculation (n=4)

Mean λmax = 4.24

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.08$

Consistency Ratio (CR) = 0.08/0.9 =0.0889

CR= 0.0889 < 0.1

Hence the pairwise judgements are trustworthy and accepted.

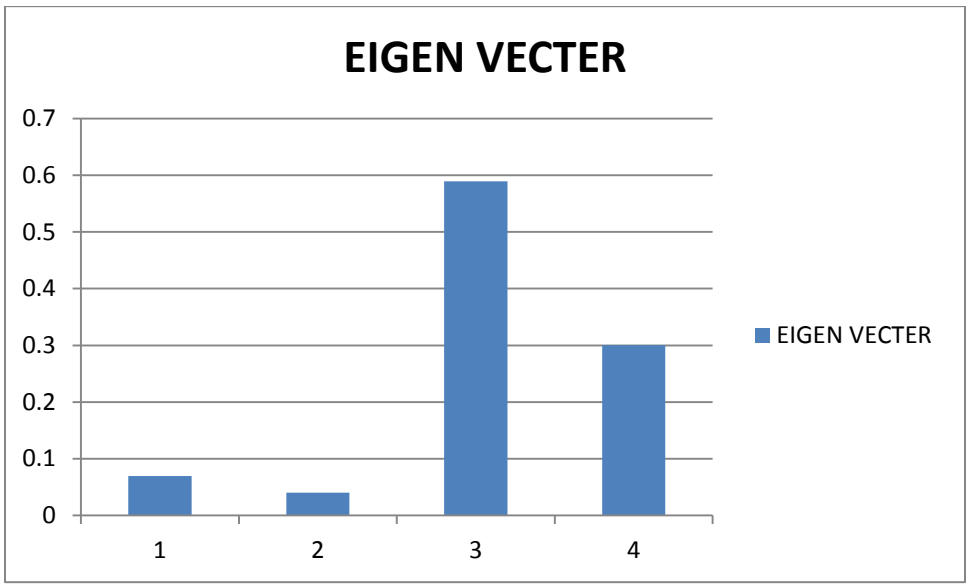


Figure 4.7: Graph of Country vs Country (Mining contribution in GDP)

4. Manpower employed

Table 4.5: Country vs Country (Manpower employed)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth root of product of value	EIGEN VECTOR (E_i)	λmax
INDIA	1	1/8	1/7	1/9	0.211	0.0344	4.354
AUSTRALIA	8	1	3	1/3	1.681	0.2744	4.152
GERMANY	7	1/3	1	1/5	0.826	0.1348	4.29
RUSSIA	9	3	5	1	3.408	0.5563	4.247
TOTAL					6.126	1.0001	

Consistency Ratio calculation (n=4)

Mean λmax = 4.26

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.086$

Consistency Ratio (CR) = 0.086/0.9 =0.09

CR= 0.09 < 0.1

Hence the pairwise judgements are trustworthy and accepted.

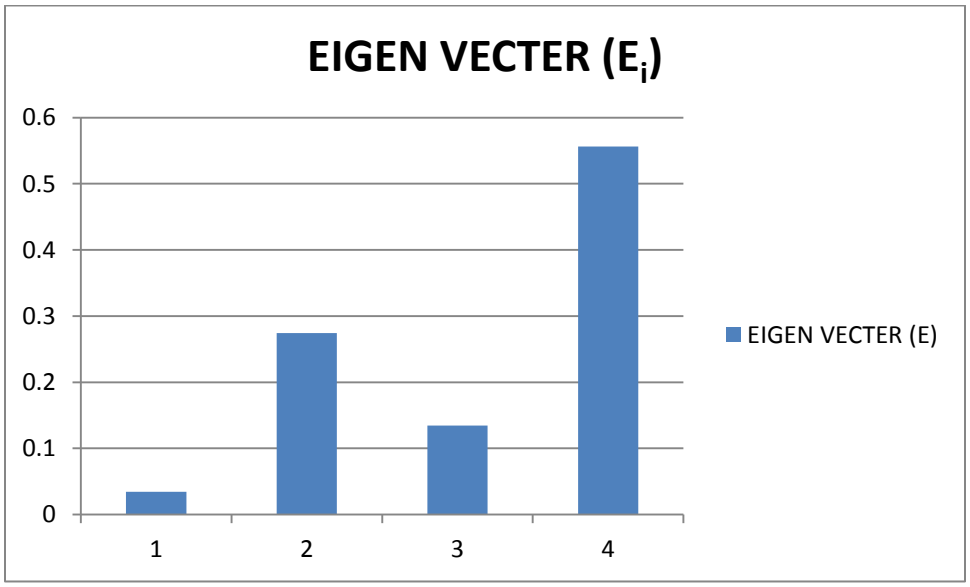


Figure 4.8: Graph of Country vs Country (Manpower employed)

5. Current Reserve

Table 4.6: Country vs Country (Current Reserve)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth root of product of value	EIGEN VECTOR	λmax
INDIA	1	1/7	1/9	1/3	0.2697	0.0406	4.272
AUSTRALIA	7	1	1/5	5	1.6265	0.2445	4.3402
GERMANY	9	5	1	7	4.2128	0.6335	4.4058
RUSSIA	3	1/5	1/7	1	0.541	0.0813	4.2117
TOTAL					6.65	0.9999	

Consistency Ratio calculation (n=4)

Mean λmax = 4.30

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.1$

Consistency Ratio (CR) = 0.1/0.9 =0.11

CR= 0.11 >0.1 (its nearest to 0.1)

Hence the pairwise judgements are trustworthy and accepted.

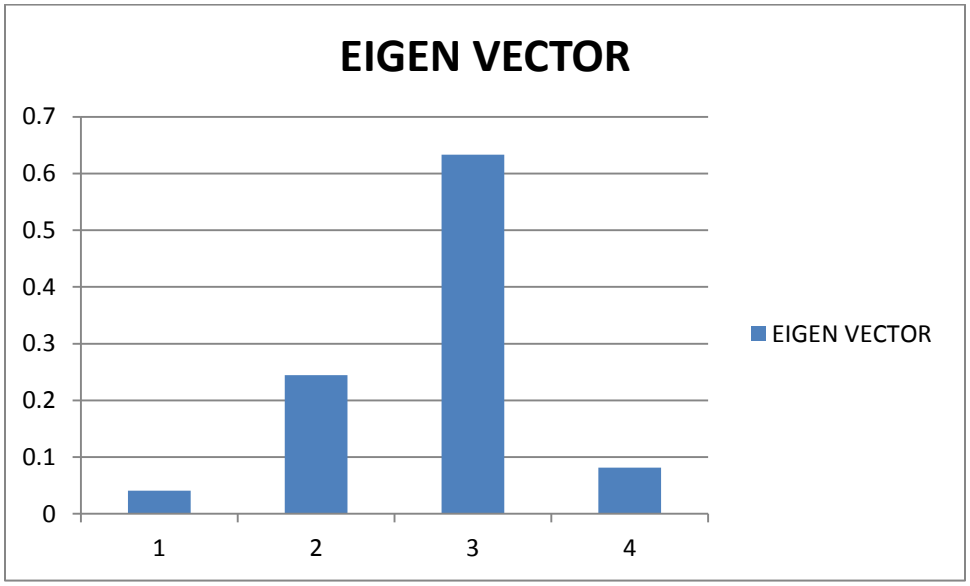


Figure 4.9: Graph of Country vs Country (current reserve)

6. Production

Table 4.7: Country vs Country (Production)

	INDIA	AUSTRALIA	GERMANY	RUSSIA	nth root of product of value	EIGEN VECTOR	λmax
INDIA	1	1/3	1/7	1/3	0.3549	0.0629	4.1785
AUSTRALIA	3	1	1/5	1/5	0.5886	0.1043	4.3484
GERMANY	7	5	1	3	3.201	0.5376	4.2684
RUSSIA	3	5	1/3	1	1.4953	0.2651	4.3549
TOTAL					5.6398	0.9589	

Consistency Ratio calculation (n=4)

Mean λmax = 4.2875

Consistency index (CI) $= \frac{\lambda max - n}{n-1}$ = 0.0958

Consistency Ratio (CR) = 0.0958/0.9 =0.1064

CR= 0.1064 >0.1 (its nearest to 0.1)

Hence the pairwise judgements are trustworthy and accepted.

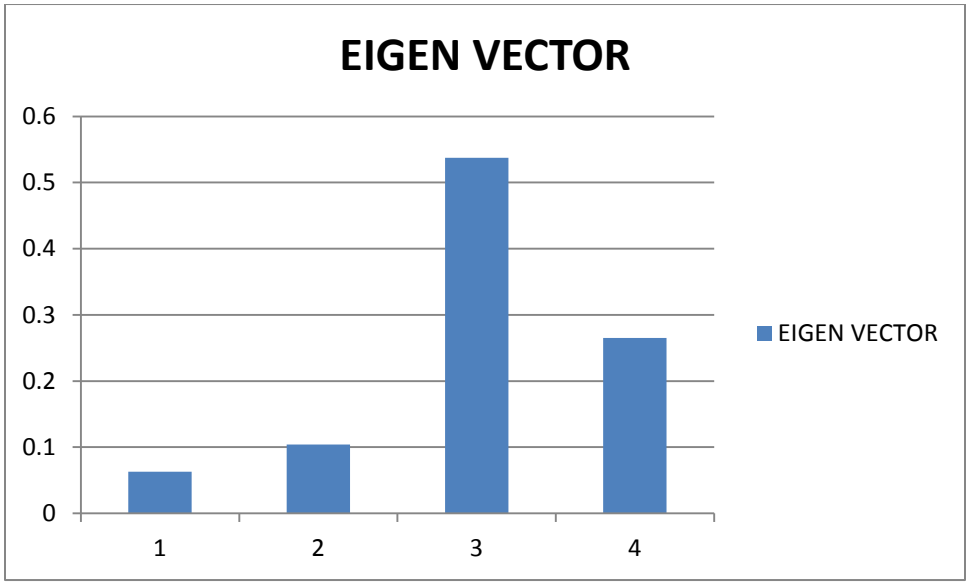


Figure 4.10: Graph of Country vs Country (Production)

Parameters vs Parameters

Table 4.8 : Parameters vs Parameters

	A	B	C	D	E	F	Ralative wt.	Eigen vector(X_i)	lmax
A	1	1/3	1/3	1/5	1/7	1/9	0.2658	0.0268	6.544
B	3	1	1/3	1/3	1/5	1/7	0.4603	0.0464	6.569
C	3	3	1	1/5	1/7	1/9	0.5529	0.0557	6.99
D	5	3	5	1	1/5	1/7	1.1354	0.1144	6.89
E	7	5	7	5	1	1/3	2.7237	0.2746	6.602
F	9	7	9	7	3	1	4.7785	0.4818	6.589
							9.9166	0.9997	

A- GDP

B- GDP Growth Rate

C- Mining contribution in GDP

D- Manpower Employed

E- Current Reserve

F- Production

Consistency Ratio calculation (n=6)

Mean λmax = 6.7

Consistency index (CI) $= \frac{\lambda max - n}{n-1} = 0.14$

Consistency Ratio (CR) = 0.14/1.24 =0.11

CR= 0.11> 0.1 (its nearest to 0.1)

Hence the pairwise judgements are trustworthy and accepted.

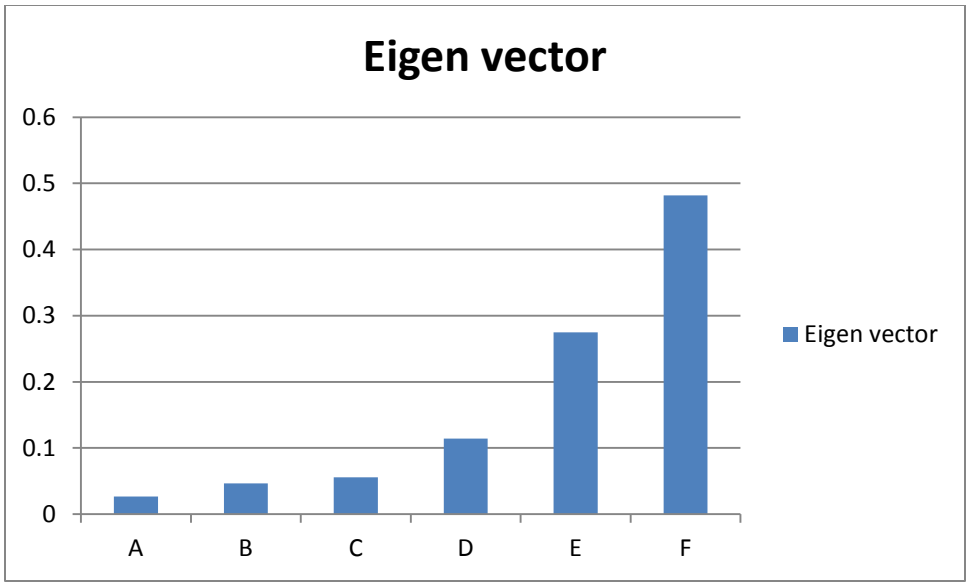


Figure 4.11: Parameters vs Parameters

Table 4.9: Judgement from tables

	C1	C2	C3	C4
P1	0.097	0.0527	0.6665	0.1833
P2	0.0416	0.3291	0.5088	0.1203
P3	0.0698	0.0403	0.5892	0.3005
P4	0.0344	0.2744	0.1348	0.5563
P5	0.0406	0.2445	0.6335	0.0813
P6	0.0629	0.1043	0.5376	0.2651

Notations

Countries (C)	Parameters Eigen Vector (P)
C1- India	P1- GDP
C2- Australia	P2- GDP growth rate
C3- Germany	P3- Mining industry contribution to GDP
C4- Russia	P4-Man power employed
	P5-Current reserves (Bt)
	P6-Production (MTs/yr)

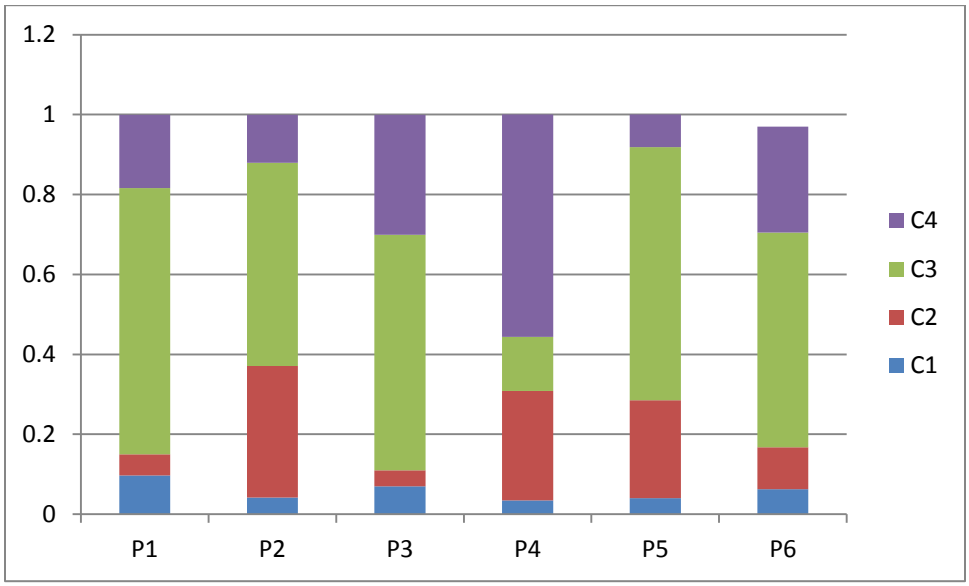


Fig 4.12: Country vs Parameters

4.3 STANDARDIZATION OF 2 MATRIXES

(Parameter vs Parameter) vs (Parameter vs Country)

1. India

Table 4.10: Normalization Matrix of E_i and X_i (India)

Eigen vector	C1	Relative weight	Normalized value
0.0268	0.097	0.0026	0.0483
0.0464	0.0416	0.0019	0.0359
0.0557	0.0698	0.0039	0.0723
0.1144	0.0344	0.0039	0.0731
0.2746	0.0406	0.0111	0.2072
0.4818	0.0629	0.0303	0.5632
		0.0538	1.0000

Table 4.11: Points calculation of India

Parameters	India	Eigen value	Points of paramters
GDP (in Billion US$)	1296	0.0483	62.614
GDP growth rate in %	880.00%	0.0359	0.316
Mining industry contribution to GDP (in%)	5.5	0.0723	0.397
Man power employed (in Lakh)	3.98	0.0731	0.291
Current reserves (Bt)	212	0.2072	43.926
production (MTs/yr)	526	0.5632	296.254
			403.799

Sum of points of all parameters for India comes out to be 403.8

2. Australia

Table 4.12: Normalization Matrix of E_i and X_i (Australia)

Eigen vector	C2	Relative weight	Eigen value
0.0268	0.0527	0.0014	0.0084
0.0464	0.3291	0.0153	0.0911
0.0557	0.0403	0.0022	0.0134
0.1144	0.2744	0.0314	0.1872
0.2746	0.2445	0.0671	0.4003
0.4818	0.1043	0.0503	0.2996
		0.1677	1.0000

Table 4.13: Points calculation

Parameters	Australia	Eigen value	Points of parameters
GDP (in Billion US$)	925	0.008	7.790
GDP growth rate in %	1.2	0.091	0.109
Mining industry contribution to GDP (in%)	5.6	0.013	0.075
Man power employed (in Lakh)	0.45	0.187	0.083
Current reserves (Bt)	75	0.400	30.025
production (MTs/yr)	335	0.300	100.378
			138.460

Sum of points of all parameters for Australia comes out to be 138.46

3. Germany

Table 4.14: Normalization Matrix of E_i and X_i (Germany)

Eigen vector	C3	Relative weight	Eigen value
0.0268	0.6665	0.0179	0.0342
0.0464	0.5088	0.0236	0.0452
0.0557	0.5892	0.0328	0.0628
0.1144	0.1348	0.0154	0.0295
0.2746	0.6335	0.1740	0.3328
0.4818	0.5376	0.2590	0.4955
		0.5227	1.0000

Table 4.15: Points calculation of Germany

Parameters	Germany	Eigen value	Points of parameters
GDP (in Billion US$)	3347	0.0342	114.3802
GDP growth rate in %	0.70%	0.0452	0.0003
Mining industry contribution to GDP (in%)	1	0.0628	0.0628
Man power employed (in Lakh)	0.59	0.0295	0.0175
Current reserves (Bt)	40	0.3328	13.3127
production (MTs/yr)	184	0.4955	91.1809
			218.9544

Sum of points of all parameters for Germany comes out to be 218.95

4. Russia

Table 4.16: Normalization Matrix of E_i and X_i (Russia)

Eigen vector	C4	Relative weight	Eigen value
0.0268	0.1833	0.0049	0.0204
0.0464	0.1203	0.0056	0.0232
0.0557	0.3005	0.0167	0.0695
0.1144	0.5563	0.0636	0.2642
0.2746	0.0813	0.0223	0.0927
0.4818	0.2651	0.1277	0.5301
		0.2409	1.0000

Table 4.17: Points calculation of Russia

Parameters	Russia	Eigen value	Points of parameters
GDP (in Billion US$)	1477	0.0204	30.116
GDP growth rate in %	3.80%	0.0232	0.001
Mining industry contribution to GDP (in%)	2.4	0.0695	0.167
Man power employed (in Lakh)	0.34	0.2642	0.090
Current reserves (Bt)	157	0.0927	14.548
production (MTs/yr)	229	0.5301	121.404
			166.327

Sum of points of all parameters for Russia comes out to be 166.327

Chapter- 5

Results and conclusion

Results and conclusion

Table 5.1: Result

Countries	Total Points
India	404
Germany	219
Russia	166
Australia	138

It is seen that India is on the forefront of the mining industry. This is primarily due to the economic stability of India. As compared to the other countries in the study India has a better economic performance and hence the lead of so many points over the other countries.

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